22

NOTE ON THE DIAGNOSTIC AND THERAPEUTIC VALUE OF THE COOLIDGE TUBE.

BY

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ɣ December 27 last the author had the honour of introducing to an assembly his American associates a man who has accomplished more for the vancement of this science than anyone except Roentgen himself.

William David Coolidge, D.S., Ph.D., is a graduate of the Boston Institute Technology and of the University of Leipzig. At present he is engaged research work at the experimental laboratories of the General Electric ›mpany at Schenectady, N.Y. Among other important achievements, he s succeeded in producing ductile tungsten, by the use of which he has vised the ignition system for gas-engines and electric furnaces. While gaged in experimental work on the substitution of tungsten in place of ıtinum for the anode of an X-ray tube, he was led to construct a tube on tirely new principles.

He believed that if a tube could be devised which should be entirely free ›m gas many of the disadvantages of the ordinary tube would be removed. ɘ introduced a cathode and anode of tungsten, supported by the sister ɛtal molybdenum, which substances are more readily freed from gas than e metals used in the ordinary tube. In this way he was able to procure vacuum 1,000 times more attenuated than that of the ordinary tube. r. Coolidge's associate, Dr. Langmuir, found that a tungsten cathode, ›ated in a highly evacuated bulb, would emit a stream of negative electrons, ıd thus provided the foundation upon which Dr. Coolidge developed his ıbsequent work.

An abstract of Dr. Coolidge's own report of the new focus-tube, published the *Physical Review* of December, 1913, appears in another portion of this urnal. I will merely mention the important features wherein it differs om other tubes.

The cathode of the Coolidge tube consists of a spiral tungsten filament hich, when electrically heated, gives off the stream of negative electrons quired for the generation of the X rays. A molybdenum sleeve around ıe spiral filament is used to focus the cathode stream upon the target. oth anode and cathode are made of tungsten. The number of electrons ven off from the cathode is regulated by changing the temperature of the ıngsten spiral. The speed of the cathode stream, and therewith the

penetrating power of the X rays, can be regulated by increasing or dimin ing the voltage on the terminals of the tube.

None but a radiographer can realise the practical advantages result from this mode of construction—viz., accuracy of adjustment, stability hardness, exact duplication of results, fixity of the focal point, long flexibility, tremendous output, and absence of indirect rays.

In the ordinary tube the penetration depends entirely upon the adj ment of its vacuum by some regulating device—a method which is h inaccurate and most unfavourable to uniform results, since the vacuum difficult to adjust and hard to sustain—whereas the hardness of the Cooli tube can be adjusted to perfect accuracy by simply regulating the curr through the tungsten filament of the cathode.

The stability of the tube is no less remarkable. In laboratory test has been run for fifty minutes without any adjustment, and with no ceptible variation in hardness, whereas an ordinary tube cannot be opera for more than a few seconds without showing material changes in penetrat

Up to the present time radiologists have found it practically imposs to obtain brilliant Roentgenograms with any degree of uniformity. With new tube it is possible accurately to adjust and sustain a given degree penetration, thus enabling us to obtain exact duplication of previous resu The Roentgenograms obtained with the new tube are not, indeed, m brilliant than selected radiograms obtained occasionally with ordinary tul but extraordinary detail of soft tissues, tendons and bloodvessels, may obtained with a far greater degree of certainty than heretofore.

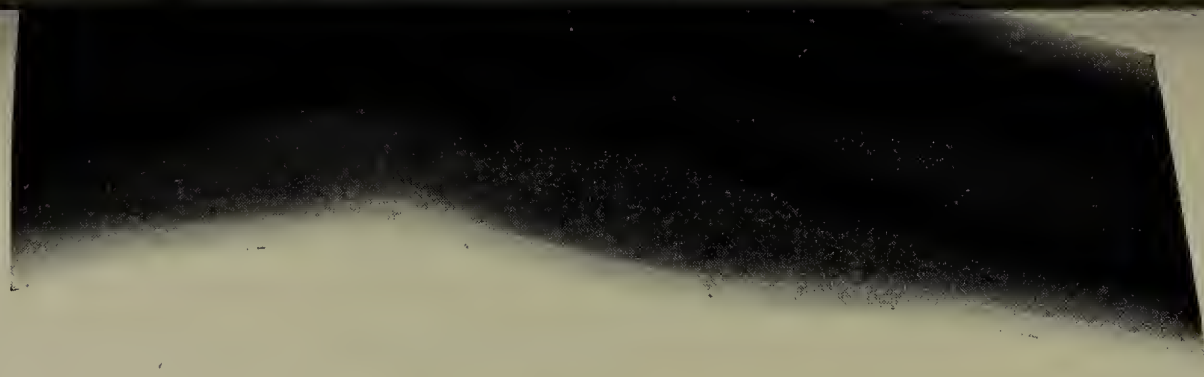
In the ordinary tube, variability of the focal spot is a factor whicl often responsible for blurring of the image, whereas in the Coolidge tube focal spot is an absolutely fixed point.

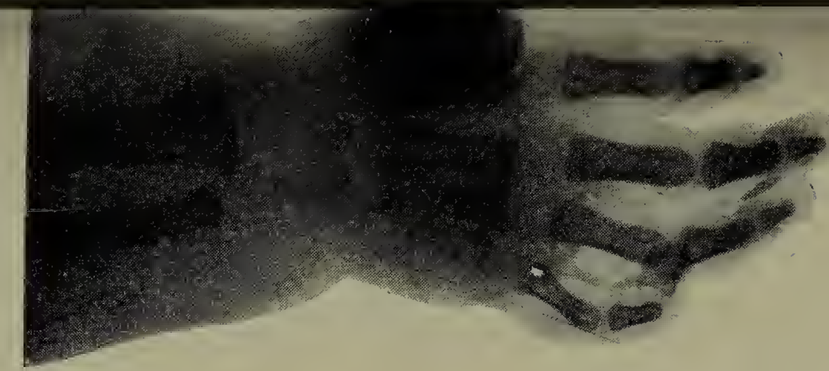
With an ordinary tube flexibility is impossible. To obtain Roentgenogr of various portions of the body, a great number of tubes of different degr of penetration are required, whereas the new tube adapts itself to ev kind of Roentgenographic and therapeutic work. It can be instantly alte from a soft tube, showing the bloodvessels in an infant's arm, to a hardn never heretofore obtained, and can be maintained at any given degree hardness for an indefinite time.

The working life of the new tube has been estimated by Dr. Coolidge be at least a thousand hours of constant running, a great increase over life of the old tubes.

Its tremendous output, both for diagnostic and therapeutic purposes perhaps the most wonderful advantage of the tube, making it especia useful in the Roentgenkinematography of the stomach and heart and in rad therapy of deep-seated cancers.

The complete absence of indirect rays in the Coolidge tube is of gr scientific interest and of practical value. The positive bodies in the ordin tube are a useless and harmful by-product, and their elimination suppres entirely both the intense heating of the tube and the fluorescence of the gl





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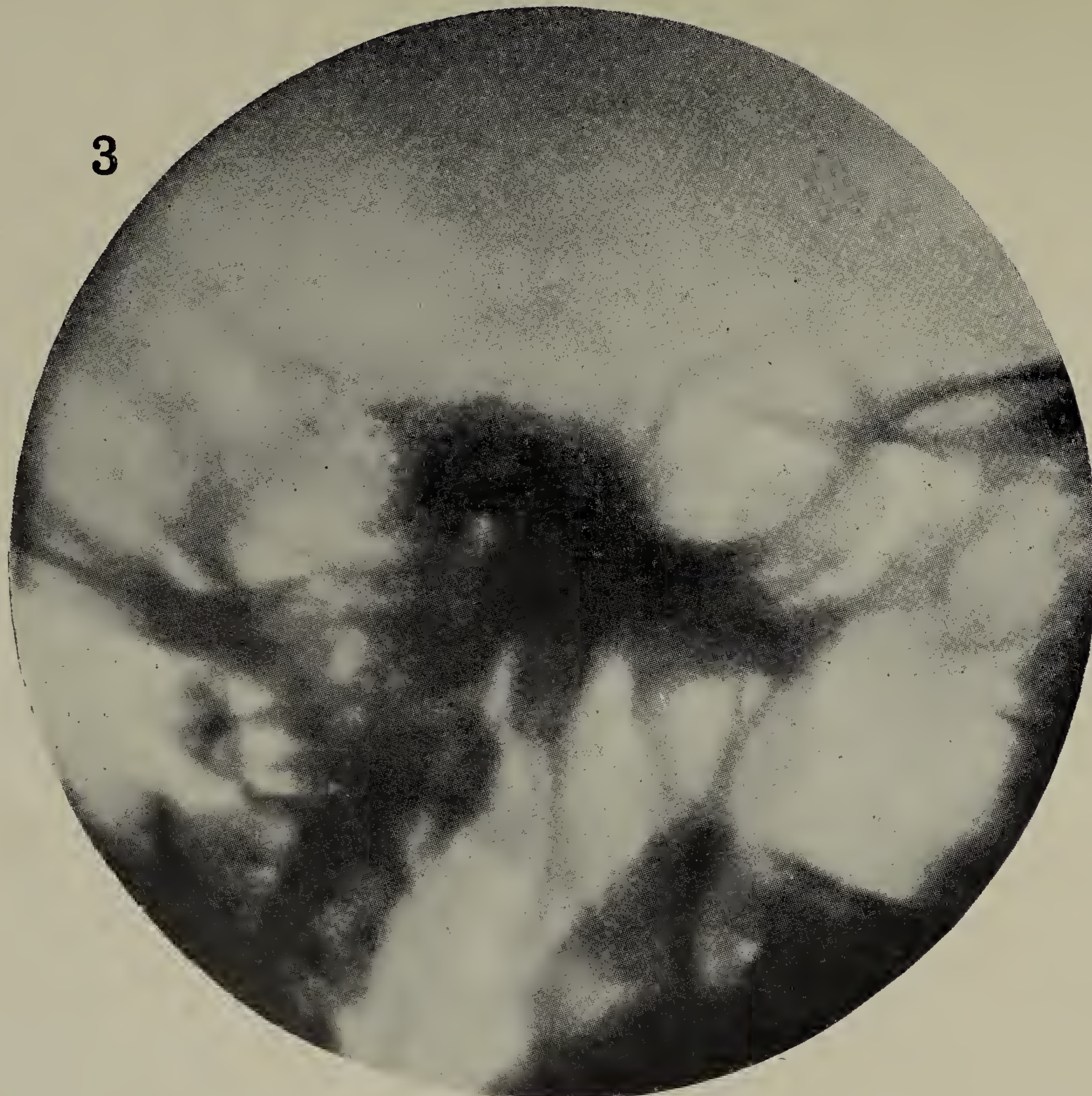

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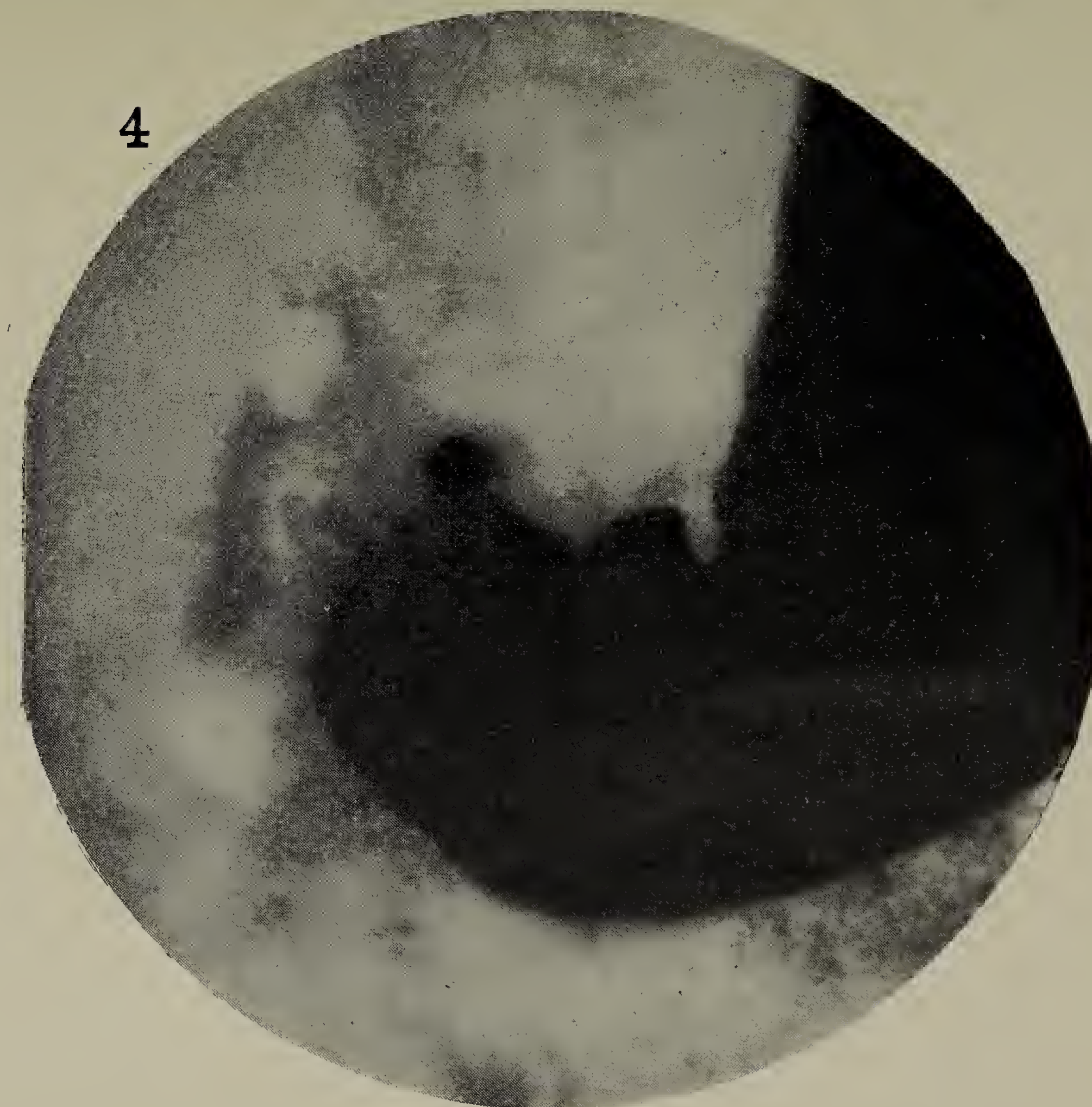


THE DIAGNOSTIC AND THERAPEUTIC VALUE OF THE COOLIDGE TUBE.

By DR. L. GREGORY COLE.

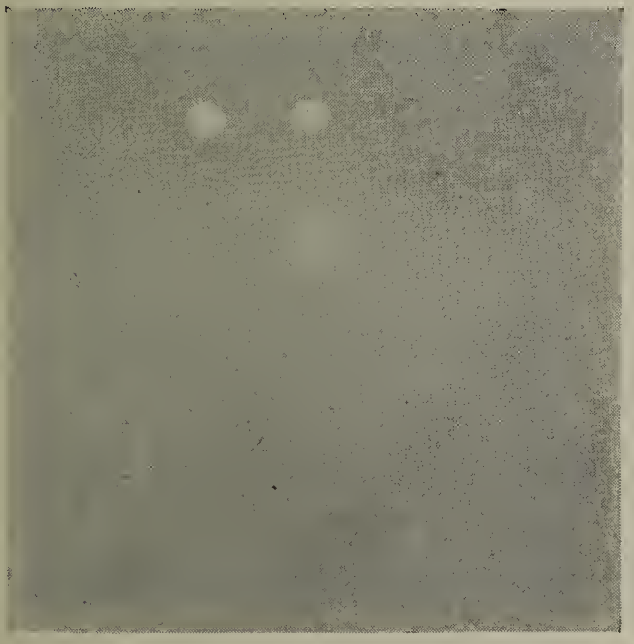
PLATE CCCCXXXVI.

ll. In the author's laboratory the tube is already being used for routine ıgnostic and therapeutic work.

A scale of hardness and milliampère-seconds necessary for the correct posure of any part of the body is appended, but this is only a rough lication which will require further verification.

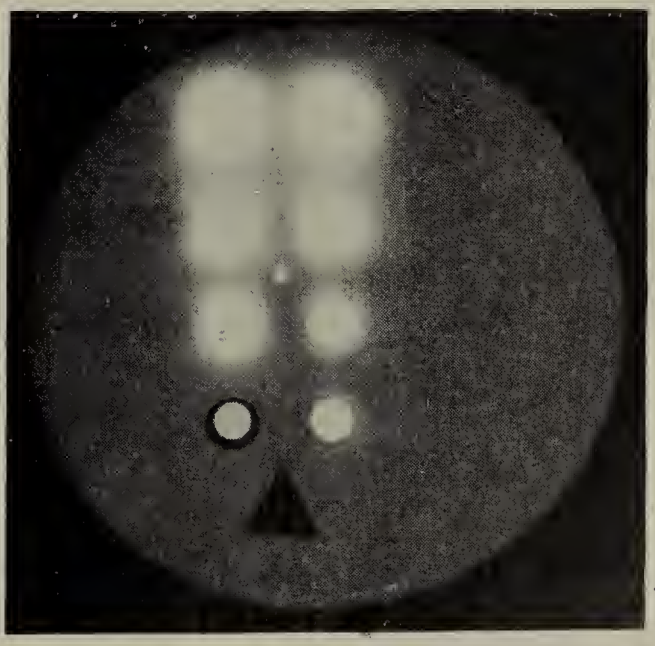
	Spark-Gap.	Current.	Time.	Milliampère-Seconds.
	Inches.	Milliampères.	Seconds.	
Hand : soft parts	$1\frac{1}{2}$–2	25	2	50
Knee : soft parts	3	25	4	100
,, bone and soft parts	4	25	4–5	125
Hip-bone	5	30	15	450
Kidney	4	30	15	450
Spine : bone detail ...	5	30	15	450
Head : lateral	5	30	15	450
,, A.P.	$5\frac{1}{2}$	40	15	600
Lungs	3	40	10	400
Stomach (screen)	5	100	·06	6

In its therapeutic application, the tremendous output of this tube, with ʒh penetration, gives a variety of X ray which is more like the gamma ʼs of radium than ordinary X rays. The treatment of deep tumours, as scribed by Kroenig and Gauss, which heretofore has required three to six urs, may now be accomplished in thirty to sixty minutes. Such a tremendous lume of highly-penetrating X rays will permit the use of adequate filters protecting the skin, and it is to be hoped that the new tube will supple-nt, or replace in great part, the use of radium.



A.

Spark-gap, $\frac{3}{4}$ inch.
Current, 10 milliampères.
Exposure, 10 seconds.



B.

Spark-gap, 8 inches.
Current, 10 milliampères.
Exposure, 12 seconds.

The accompanying figures show two Roentgenograms of the Walter netrometer to demonstrate the flexibility of the tube. A was made with ı exceedingly soft tube, the parallel spark-gap being under 1 inch. B was ade an instant later with the same tube, adjusted to a penetration that read

beyond the Walter scale. It will be seen that the rays readily passed thro the thickest platinum disc, and even through the surrounding lead.

The following tests will show the therapeutic efficiency of the Cooli tube. For these experiments a Hampson radiometer was used. A piec beef 2 inches thick was irradiated by a Coolidge tube, at a focus dista of $5\frac{1}{2}$ inches. An aluminium filter 3 millimetres thick was interposed betw the tube and the beef. One Sabouraud pastille was placed on the surfac the beef, a second pastille 1 inch below the surface, and a third past under 2 inches of beef.

Experiment I.—The tube was regulated so that the parallel spark- was $7\frac{3}{8}$ inches. The Bauer penetrometer indicated far beyond the registe scale. The Walter penetrometer registered 8 +. An exposure of three a half minutes was made. During this time the milliampèrage varied fr 10 to 8 and back to 9. The pastille on the surface read 12 H., or three tir the erythema dose. The pastille 1 inch deep read 6 H., or one and a h times the erythema dose, and the pastille 2 inches below the surface 3 or about three-fourths of an erythema dose.

Experiment II.—The spark-gap was again $7\frac{3}{8}$ inches, the Walter pe trometer 8 +, and the milliampèrage from 8 to 10. An aluminium fil 3 millimetres thick was interposed, and a series of four one-minute exposur followed by a two-minute exposure, was made on a similar piece of beef.

With a one-minute exposure the pastille on the surface read 4 H.

After the second exposure of one minute, making a total exposure of t minutes, a second pastille on the surface read 4 H. The pastille an in deep, exposed for a total of two minutes, read 3 H.

After the third one-minute exposure, a new pastille on the surface aga read 4 H. The pastille an inch deep, exposed for a total of three minut read 4 H.

After the fourth one-minute exposure, a fourth pastille on the surface re 4 H. The pastille an inch deep, exposed for a total of four minutes, read 6 I and the pastille 2 inches deep read 3 H.

After a fifth exposure of two minutes, the fresh surface pastille read 8 The pastille 2 inches deep read 4 H.

The above tests show that by using six ports of entry one may obtain full erythema dose 2 inches below the surface in six minutes. With th tremendous amount of highly-penetrating rays, any amount of screenin desirable may be used without prolonging the treatment beyond a reasonab time.

It must be noted, however, that the Coolidge tube is like a two-edge sword—capable of doing great damage unless manipulated with the utmo care. The danger is especially insidious in that there is no evidence of th action of the tube during its operation. With an ordinary focus-tube considerable exposure of several minutes is without danger to the patien With the full capacity of the new tube, however, serious and even fat burns may be caused in much less than a minute. A note of warnin

ould therefore be added to the announcement of an achievement which undoubtedly the most remarkable of its kind in the present age.

The four radiographs shown on Plate CCCCXXXVI. give some idea of e flexibility of the new tube.

Fig. 1.—Radiograph of child's arm, taken with a Coolidge tube of exceed-gly low penetration. The negative showed the contour and structure of e bones, the various layers of muscle, the pronator quadratus, bloodvessels, d lobules of subcutaneous fat, very distinctly.

Parallel spark-gap, 3½ inches; current, 70 milliampères; exposure, second.

Fig. 2.—Hand of a child, showing remarkable detail in the soft tissues, pecially the thumb tendons.

Parallel spark-gap, 3 inches; current, 70 milliampères; exposure, second.

Fig. 3.—Lateral view of a tumour of the hypophysis, showing distortion the anterior and posterior clinoid processes, an area of increased density the anterior part of the sella turcica, and a localised area of increased nsity in the gland. Taken immediately after Fig. 1 with the same focus-be, but adjusted for very hard rays. The contour and structure of the nes is revealed in a manner which would lead one to believe that the entgenogram was made from a skull devoid of soft parts.

Parallel spark-gap, 5 inches; current, 40 milliampères; exposure, seconds.

Fig. 4.—One of a series of ten plates of the stomach. The total time quired for taking the series was $\frac{6}{10}$ second. The radiograph shows a stortion of the duodenal cap due to post-pyloric ulcer.

Parallel spark-gap, 5½ inches; current, 110 milliampères; exposure, 6 second.

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